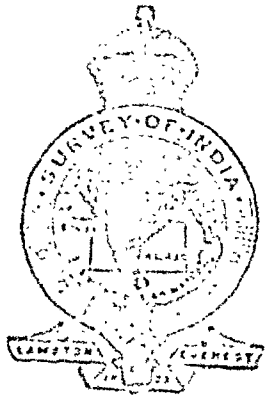
SURVEY OF INDIA



AIR SURVEY

FOR

DEVELOPMENT

PUBLISHED BY ORDER OF
THE SURVEYOR GENERAL OF INDIA

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INDEX

AIR SURVEY FOR DEVELOPMENT

1. **Introduction.**—The object of this pamphlet is to outline the use and limitations of air photography and air survey in relation to development projects.

Nearly every project requires survey before any useful planning can be done.

For some projects the existing topographical map sheets of the Survey of India on the scale of 1-inch or ½-inch to 1 mile are enough to start with but in most cases fresh surveys on larger scales become necessary sooner or later.

The Survey of India is fast expanding to meet post-war needs in India but economy in survey processes will be necessary for some time to come.

For many purposes air survey effects great economy whilst affording adequate results which may be available very quickly.

In other cases ground survey or a combination of air and ground survey may be preferable.

The Survey of India is glad to advise on the most effective and economical type of survey for any particular purpose, on request.

These notes indicate the information which should be given in making demands and illustrate some methods of the application of air photography and air survey to practical planning.

2. **Organization.**—In addition to the maintenance of ordinary topographical maps of India the Survey of India has parties or, at need forms special parties, with the approval of the Government of India, to undertake special surveys for development.

Many projects are already in hand but new demands are constantly being dealt with and photographic facilities which can be turned to the purpose of air surveys are available.

All enquiries concerning air photography and air survey should be made to the ~~Regional Survey Director concerned (see map at page 17). When in doubt a reference should first be made to the~~ Deputy Surveyor General, Old Secretariat, Delhi.

The enquiry should state the scope of the project, the particular aspect or aspects of project planning for which the survey is required and scales which it is suggested may be suitable. The target date for completion should also be stated if the matter is urgent.

3. **Air Photographs.**—The basis of air survey is air photographs and usually these are taken with the aerial camera pointing vertically downwards. For a few highly specialized uses, photographs are taken with the camera pointing away from the vertical but, in general, these are only of value for the pictorial effect and for publicity purposes and are not further considered here.

Vertical air photographs somewhat resemble an ordinary line-map if the ground photographed is flat. The scale depends on the height above ground from which the photograph was taken and the focal length of the lens used.

Photographs differ from a line-map in the following respects :—

(i) One photograph only covers a limited area.
(ii) Unless the area is flat the scale varies.
(iii) Small but important features may be invisible unless the scale is very large.
(iv) Trees obscure features beneath them.
(v) Shadows may obscure detail although they may help to identify tall thin objects such as pylons, chimneys and telegraph poles.
(vi) Buildings obscure detail at their foot when they are away from the centre of the photograph.
(vii) Line-maps can readily be annotated with planning notes : photographs are less suitable for this.

Nevertheless, for some purposes, simple photographs suffice for preliminary planning and take very much less time to produce than line-maps : they are useful for crop investigations, forestry, geological surveys, archæological surveys, soil conservation, or to illustrate where works are necessary.

4. Enlargements and rectifications.—Photographs of flat ground taken with special care, can with the aid of a minimum of ground measurements, be rectified to form photo-maps of sufficient accuracy for precise measurements for making revenue records and for town planning or factory lay-out.

The cost of photography increases very much as the scale increases. Enlargement of small scale negatives to larger scale prints, however, affords a means of getting a larger scale and hence clearer pictures at a cost considerably less than that of direct photography at the larger scale. Up to 2½ times enlargement generally gives satisfactory results : beyond that, clarity diminishes.

Enlargement is therefore often resorted to and is particularly useful when small scale photographs will do for general planning purposes over a wide area within which larger scale prints of selected areas are needed for more detailed study and can be produced by enlargement from the small scale negatives.

5. Air-photo mosaics.—Air photographs of flat ground can be fitted together and stuck down to form a mounted mosaic for use as a photo-map of larger areas than can be covered by a single photograph. These may be specially useful for factory lay-out or river-training.

Satisfactory mosaics of hilly or mountainous country cannot be made because the land at different elevations in the same photograph varies in scale. This gives rise to a complicated distortion of the ground surface appearing in the photograph and in attempting to mosaic some land is duplicated and some is lost. Such photographs can only be converted to useful maps by survey plotting.

As a partial exception to this, mosaics of proposed hill-reservoirs can be prepared when the total depth of the reservoir is small compared with the height of the photographic aircraft. In such cases, the area of importance (the reservoir area) photographs nearly flat and permits mosaicing and contours can be added which permit of capacity calculations to within a small percentage of error but the area outside the reservoir zone is subject to larger errors and cannot be used for calculations.

6. Stereoscopy.—A stereoscopic view, that is to say a view in relief, is obtainable from two photographs of the same object taken from different angles. This principle is applied in air photography for survey and offers two advantages :—

(i) It enables the nature of objects to be accurately determined ;

(ii) It enables the shape of hills to be seen and, accordingly, contouring to be done when height control exists on the ground.

Air photography for map making is therefore taken so that every bit of country to be mapped is covered by at least two adjacent photographs. This is done by taking photographs in straight strips so regulated that each photograph on a strip overlaps the next by more than half.

For planning for development, " stereoscopic pairs " of photographs can be supplied for examination by the planners and, generally speaking, a little practice makes them easily readable to any one of normal good vision (see page 16).

7. Line-maps from air photographs.—A line-map from air photographs is not different in essentials from a line-map prepared by ground survey methods but in some circumstances it has advantages.

Photographs can be rapidly taken at suitable seasons and the accessory work required on the ground is limited to plan and height-control and entry of information not seen in the photograph. Once these are done any portion of the work can be taken up in the office at will.

Moreover in certain types of terrain, line-maps from air photographs of accuracy equivalent to or even better than maps from ground survey can be made more quickly.

There are two stages in line-mapping from air photographs after the photographs have been taken and accessory ground work done and certain preliminary office work has been completed.

The first is the mapping of detail or planimetry and the second is the mapping of the relief or orography.

This is often convenient for the indentor who may be able to make considerable use of the planimetry alone and this is generally ready considerably in advance of the contours which are used to show relief.

8. Illustrations.—The following pages illustrate a few selected examples of the uses to which air photography and air survey can be put.

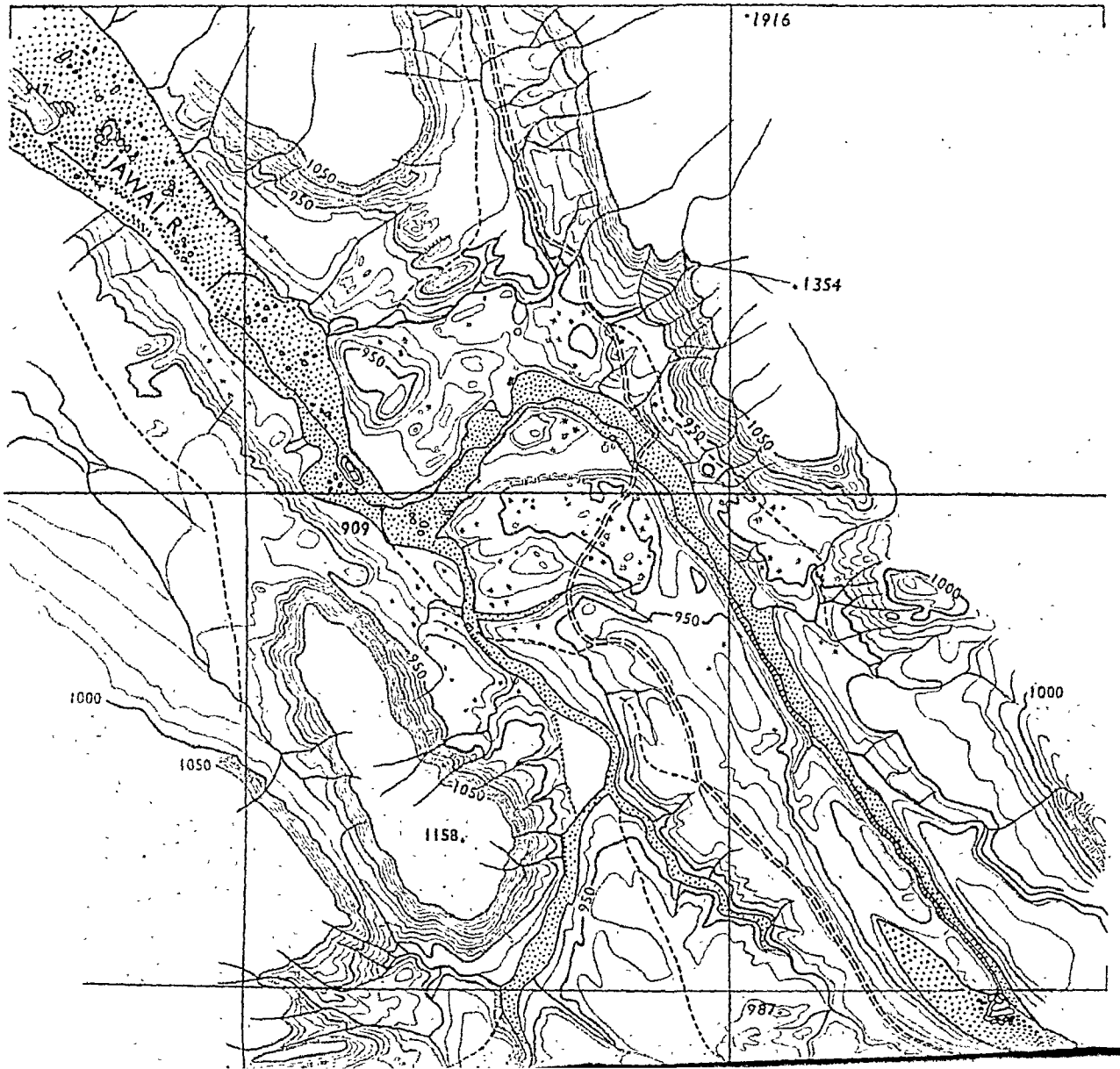
No indication of cost is given since, apart from variations in cost of material and labour, every task has special conditions which cause actual cost to vary between wide limits.

Estimates will be provided by Regional Directors for any task on application but final charges are based on actual costs.

9. Special Note.—Reproductions of air photographs in this pamphlet are lithographic "half-tones" in which clarity is considerably less than the clarity of photographic bromide prints which are normally supplied to indentors for planning purposes.

Lithographic half-tones are only made when large numbers of prints are required for publicity or information of those who are not required to plan constructively.

The photographs were taken by the Indian Air Survey and Transport Co. Ltd., Dum Dum. These and the maps are reproduced with acknowledgements to the respective indentors.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IRRIGATION & HYDRO-ELECTRIC PROJECTS

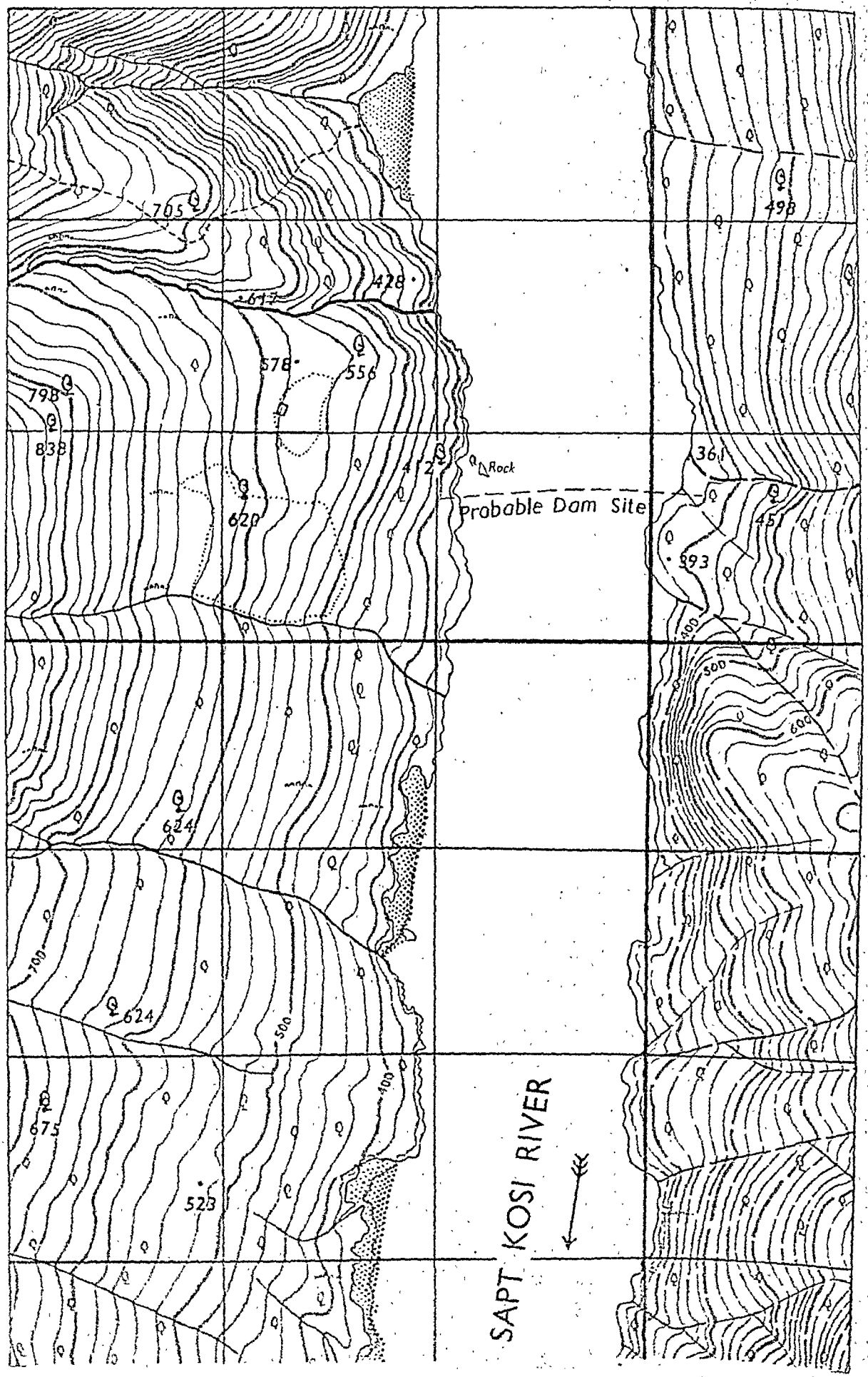
(RESERVOIR INVESTIGATIONS)

For irrigation projects it may be necessary to form a rapid preliminary appreciation to determine whether a project is worth pursuing at all. In such investigations the probable capacity of potential reservoirs is clearly important.

This information can be obtained most rapidly and cheaply in the majority of cases from contoured mosaics from which capacity can be calculated to an accuracy of about 5%.

Once the decision as to location of the reservoir has been taken, a line-map will probably become necessary for more precise calculations as well as for detailed planning and examination of what will be submerged. The illustrations opposite show a contoured mosaic of Erinpura Reservoir in Jodhpur State on a scale of about 6-inches to 1 mile with contours at 10 ft. vertical interval and, overlying this, the line-map subsequently prepared from the photography used for the mosaic.

Scale and contour interval should be selected according to the terrain. As a rule a scale of 4-inches to 1 mile will do, the contour interval depending on the steepness of slope. In very heavily wooded country, supplementary ground work may be considerable and in some cases ground survey alone may be preferable but is generally too expensive to embark on for provisional selection of reservoirs.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SAPT KOSI RIVER

IRRIGATION AND HYDRO-ELECTRIC PROJECTS (DAMS)

Maps for Dam sites are usually needed on a scale of at least 16-inches to 1 mile.

Maps on this scale can be made from 16-inch enlargements of air photography on about scale 6-inches to 1 mile. Contour intervals are usually at 5 or 10 ft. vertical interval according to the terrain.

Maps on 32-inch scale can be made from 12-inch photography enlarged. Such a large scale is usually only necessary in the high hills where the contour interval may be greater.

The illustration opposite shows part of the map prepared on scale 32-inches to 1 mile with 20 ft. contours for detailed investigation of the KOSI Dam, (Nepal).

For engineering purposes, still larger scale maps are needed but air survey is not suitable for these.

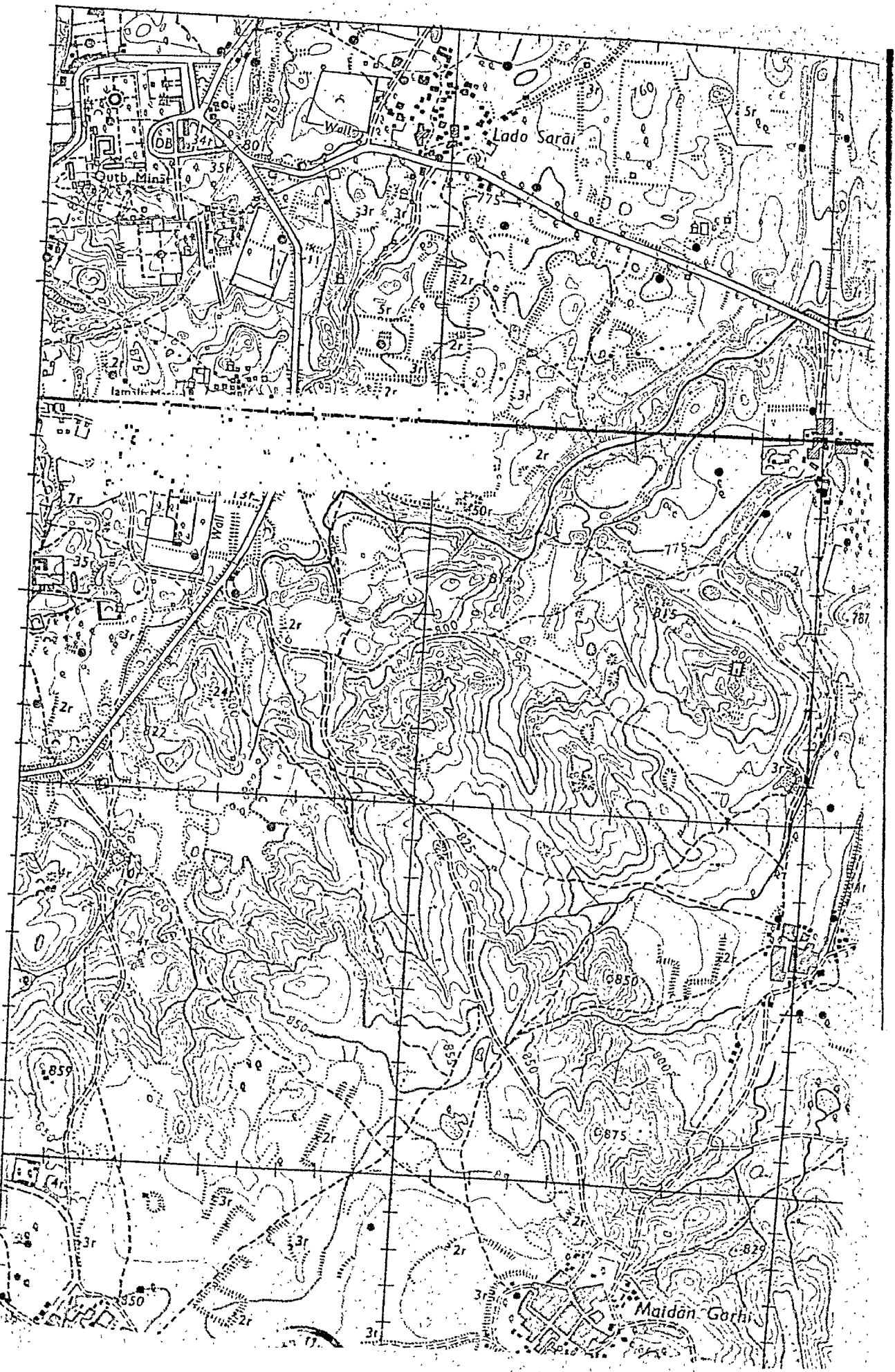
IRRIGATION PROJECTS (COMMANDED AREAS)

Survey for irrigation projects, including canalisation, reclamation of spoilt land and flood control have assumed particular importance in recent times.

Such surveys have hitherto been carried out entirely by ground survey.

Surveys for numerous major projects of this nature are now in hand and are, in most cases, being done by a combination of air and ground survey.

No illustrations are yet available but an illustration will shortly be issued to insert opposite. The accepted scale for such surveys is usually 4-inches to one mile. Contour interval varies between 1 foot and 5 feet depending on the nature of terrain.


Lado Sarai
Qutb Minar
Wall
Maidan Garhi

PRELIMINARY TOWN-PLANNING

For development of urban areas a necessary preliminary is often a map on medium scale of 4-inches or 6-inches to 1 mile. The illustration opposite shows a portion of New Delhi on the scale of 6-inches to 1 mile with contours at 5 ft. vertical interval.

The planimetry (detail) was prepared by air survey based on ground-control, contours being added by ground survey on working prints of planimetry.

As a rule the 4-inch scale is likely to be adequate for this purpose and the contour interval would vary depending on the type of terrain.

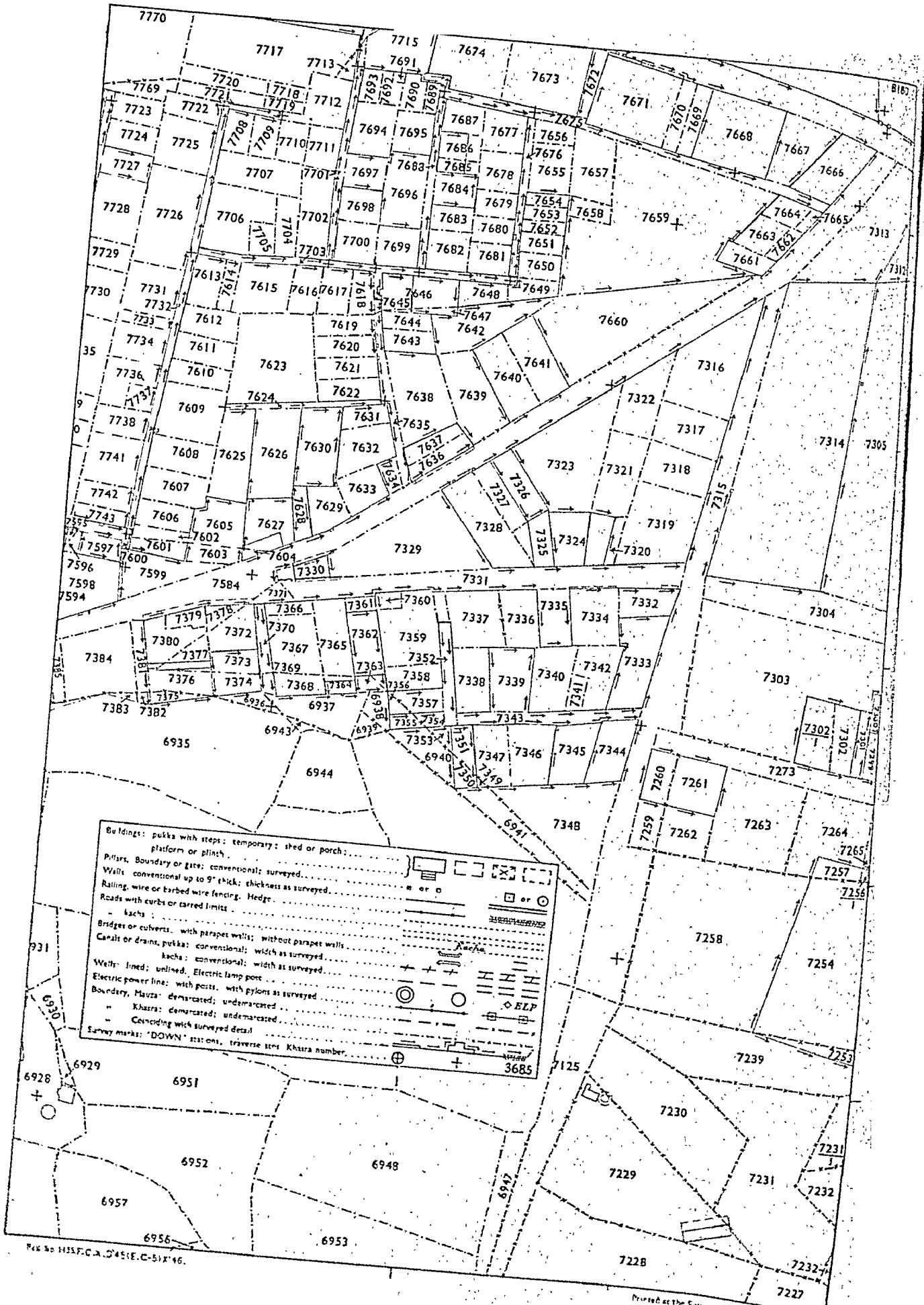
TOWN PLANNING

For more detailed planning than can be done on a medium scale map as in the previous illustration, maps on scale 16-inches to 1 mile are likely to be required. As a rule the expenditure on production of line-maps at this scale, prior to planning, is probably unjustified since the survey would have to be completely revised after development.

For this purpose, therefore, the map may well be a photo-map. The illustration opposite shows part of Delhi on the scale of 16-inches to 1 mile.

Large mosaics are usually mounted on masonite boards which can be cut into convenient sizes for handling, the various sections being butt-jointing. In the unlikely event of a large number of such mosaics being required copies could be printed by the lithographic half-tone process in any number required but more usually a few copies are only likely to be necessary and these can be prepared on photographic bromide paper.

Mosaics such as the above are only recommended in flat areas and even then accurate measurements from them cannot be expected. Where accurate measurements are necessary rectified enlargements of individual prints on 16-inch scale are necessary similar to those illustrated opposite page 11.


Buildings: pukka with steps; temporary; shed or porch; platform or plinth
Pillars, Boundary or gate; conventional; surveyed
Walls conventional up to 9" thick; thickness as surveyed
Railing, wire or barbed wire fencing. Hedge
Roads with curbs or tarred limits
" kachs
Bridges or culverts. with parapet walls; without parapet walls
Canals or drains, pukka; conventional; width as surveyed
kachs: conventional; width as surveyed
Wells: lined; unlined. Electric lamp post
Electric power line; with posts, with pylons as surveyed
Boundary, Mauza: demarcated; undemarcated
" Khasra: demarcated; undemarcated
" Coinciding with surveyed detail
Survey marks: 'DOWN' stations, traverse sta. Khasra number
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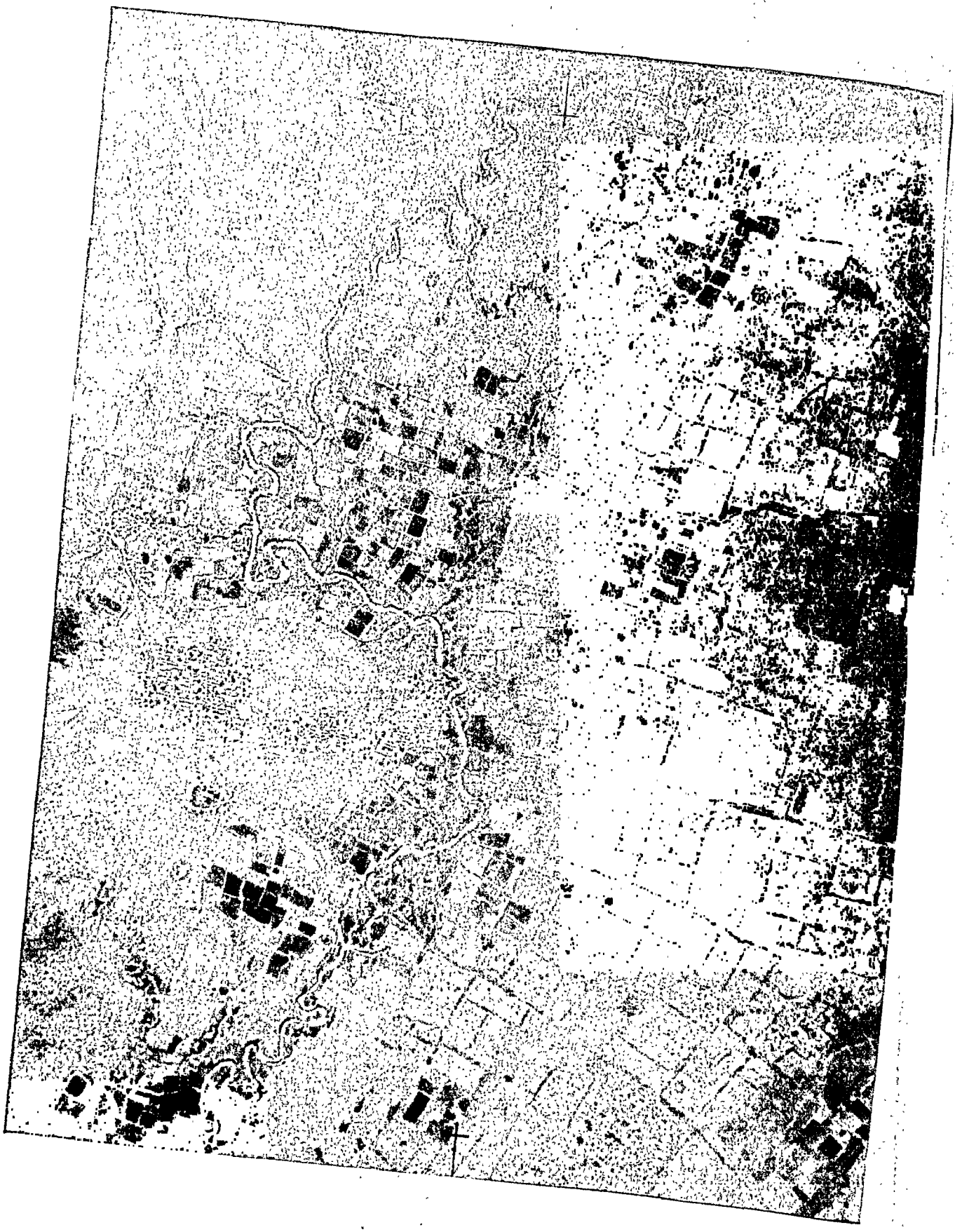
TOWN SURVEYS

Although as stated on the previous page, expenditure on large scale line-maps for planning is usually unjustifiable in areas liable to much change, extra large scale surveys which may subsequently be useful as basis for record of property rights may well be desirable and may justify expenditure at planning stage.

The map opposite shows part of the Town Survey of a partially developed area of Lahore on the scale of 100 ft. to 1 inch (52·8-inches to 1 mile). This was done entirely by ground survey.

Similar survey is now in hand of undeveloped areas of New Delhi but, in this, a method combining air and ground survey is being used for detail whilst contours are being done entirely by ground survey.

Surveys on scales yet larger than this may be needed in congested developed areas but air survey is not recommended for such larger scales.

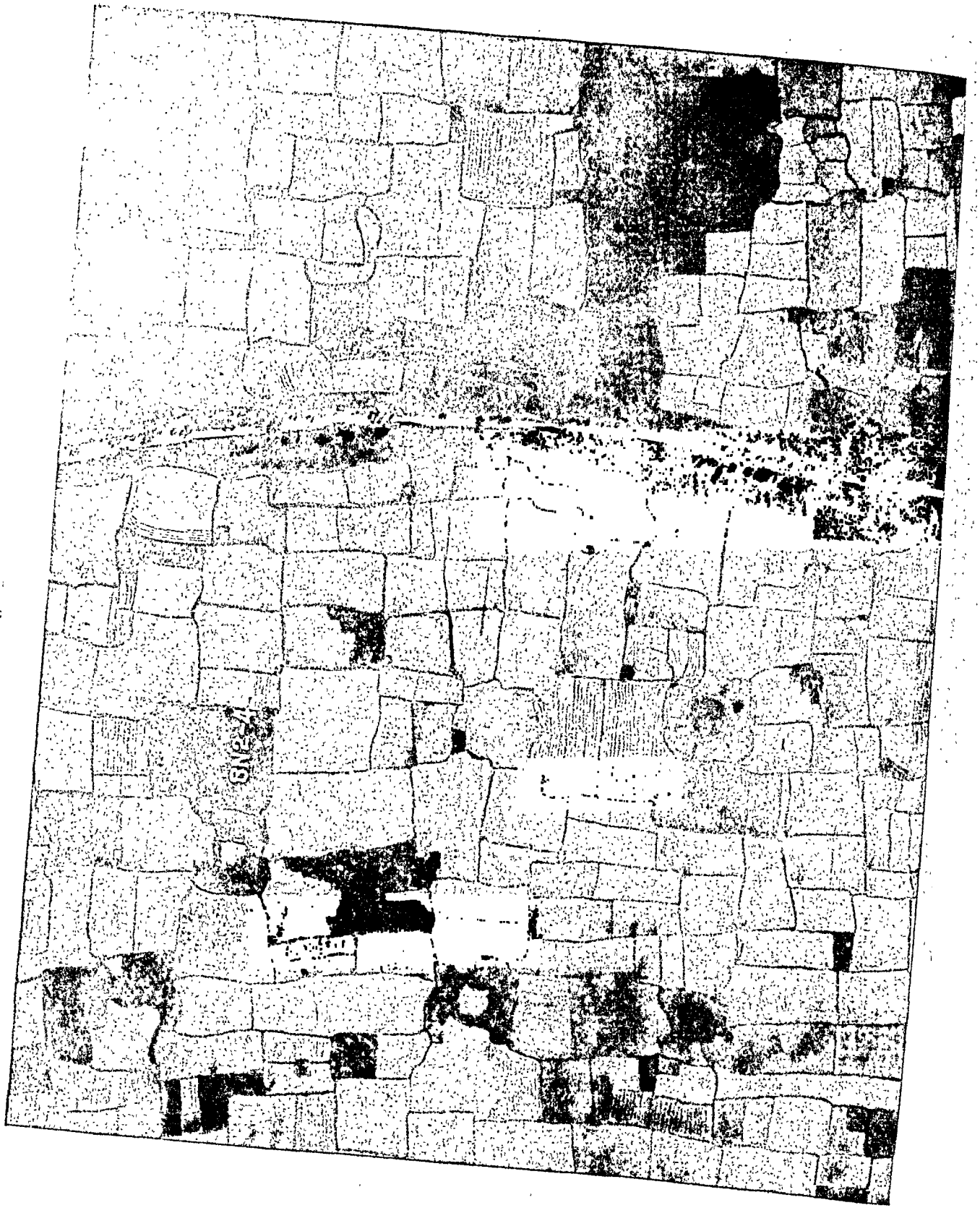


CROP INVESTIGATION

In flat country areas can be taken out from unrectified prints of photographs, which have been taken with particular care, by tracing on a tale overlay. The areas are extracted from the overlay with an acre comb and multiplied by the factor for the photo scale. Accuracy for small areas should be to about 5% and for large areas to about 2%.

A suitable scale for photography is about 2-inches to 1 mile for enlargement to 4-inches to 1 mile for taking out areas. The method is usually confined to compact areas. The illustration opposite shows an unrectfied print on an approximate scale of 4-inches to 1 mile.

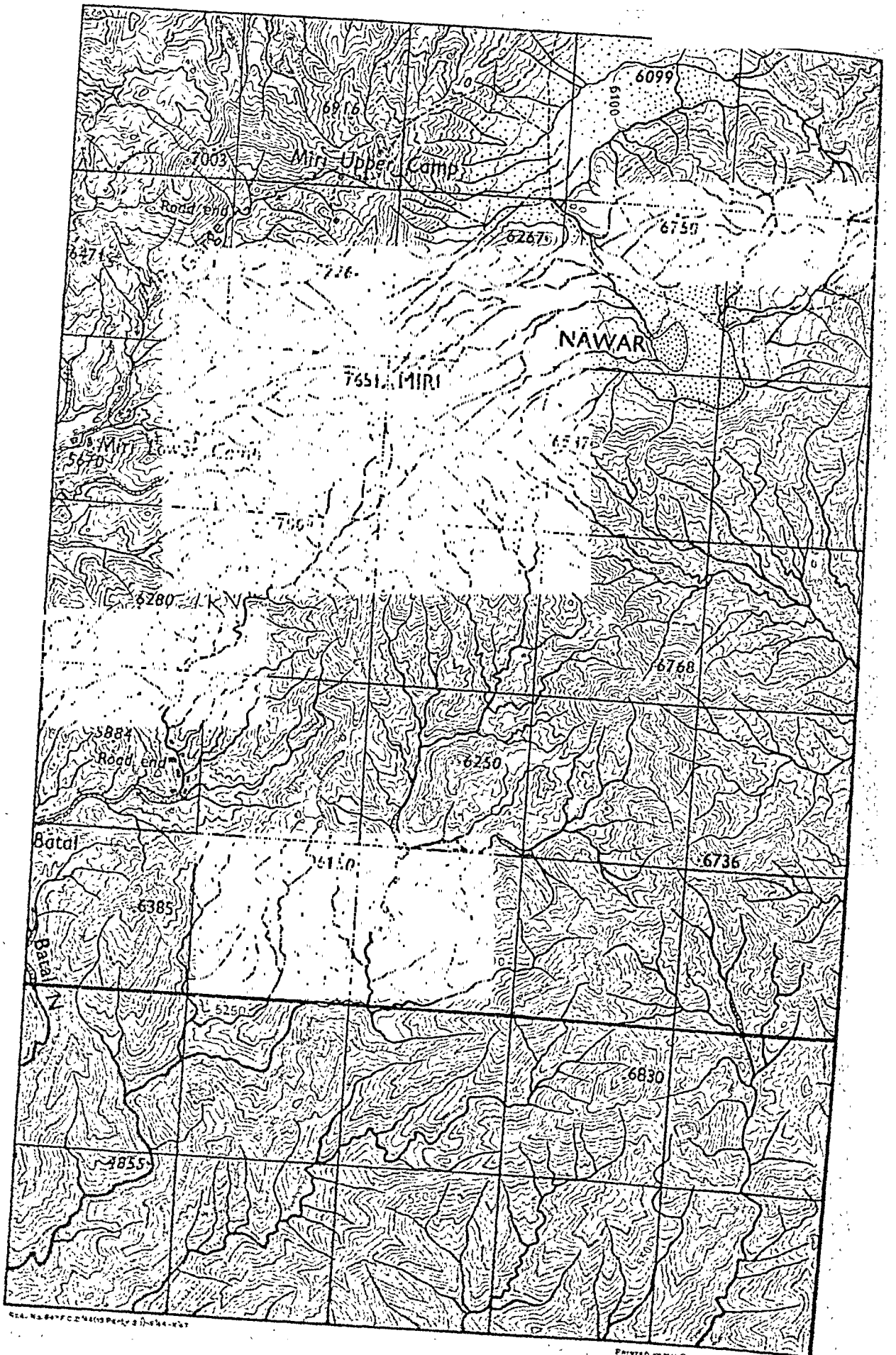
Experiments are in hand to determine whether the types of various standing crops can be ascertained solely by interpretation of air photographs. If this proves feasible it may be possible to use photographs to forecast crop yield in *Rabi* and *Kharif* areas by "sampling". That is to say by taking photographs of small selected representative areas and applying the statistics obtained to wider areas in the same locality.



REVENUE SURVEYS

The illustration opposite is a rectified enlargement on the scale of 16-inches to 1 mile prepared from an air photograph on the scale of 6-inches to 1 mile. Such prints are usually supplied on non-distorting paper probably based on foil or zinc for use in the field as a *musavi*. The field work is subsequently traced and printed for use as a revenue line-map.

In flat country, this type of survey is as accurate as ground survey but needs a good deal of ground control as basis for rectification.



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MINERAL SURVEYS

In conjunction with the Geological Survey Department, surveys are carried out for exploitation of mineral deposits.

The scale of 1/25,000 (about 2½-inches to 1 mile) is usually suitable; contour interval depends on the nature of the terrain.

The illustration opposite is a line-map on 1/25,000 scale with contours at 50 ft. vertical interval in the sulphur-mine area of KOH-I-SULTAN, Chagai District, Baluchistan.

SOIL CONSERVATION

The necessity for afforestation and/or "bunding" to counteract soil-erosion is too well recognised to need emphasis. Air photography forms a cheap and easy means of providing data for planning anti-erosion measures. As a rule photographs alone will do and no special survey is necessary although key maps may be necessary for systematic record of planning measures and special levelling on the ground may be necessary for "bunding".

The envelope opposite contains a stereoscopic pair of enlargements on the scale of 4-inches to 1 mile (from photography on scale 2-inches to 1 mile) of part of the Lachiwala Forest near Dehra Dun.

The print opposite shows eroded land near Sukho, Gujar Khan Tahsil, Punjab on the scale of 2-inches to 1 mile. Mosaics on about 2-inch scale are useful for a general consideration of anti-erosion measures and 4-inch enlargements are recommended for stereoscopic examination of areas selected for afforestation or "bunding".

ROAD OR RAIL ALIGNMENT

Generally speaking, for road or rail alignment, examination of the best available topographical maps will give sufficient information for selection of a few probably practicable alignments.

When this has been done, air photography on a scale of about 2-inches to 1 mile of the alternative alignments for production of prints for stereoscopic examination, will probably be enough to carry selection of ultimate alignment to the road/rail engineering survey stage which is carried out by the constructing staff. Enlargements of selected areas are useful for detailed examination.

In the envelope opposite are enlargements on the 3-inch scale which can be examined stereoscopically.

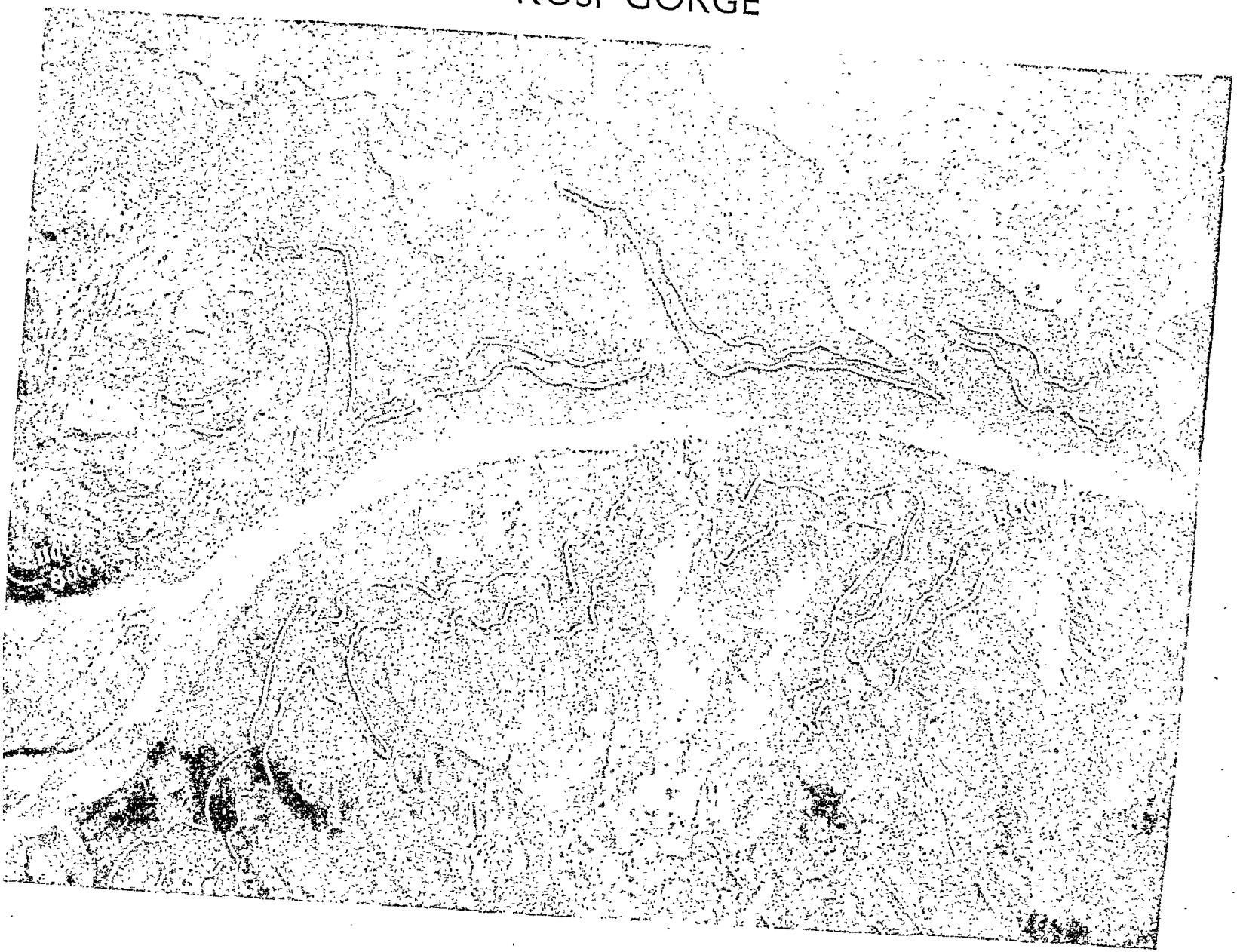
These show a portion of the Dehra Dun Chakrata road.

4-inch enlargements are usually recommended.

A note on the use of the stereoscope is at page 16.

TONS RIVER

KOSI GORGE



ANAGLYPHS

For reports or other purposes when it is desired to provide a view in relief on an extensive distribution to those who are not likely to possess stereoscopes, ANAGLYPHS are useful. These afford a reasonably good view with the aid of cheap coloured spectacles which can accompany the anaglyph.

The views opposite are anaglyphs and can be viewed in relief with the spectacles in the envelope at the foot of this page.

The first view is the same as the stereo-photo-pair opposite page 14.

The second view is part of the KOSI GORGE and is reproduced with the permission of the Chairman, Central Waterways, Irrigation and Navigation Commission for whom it was originally prepared.

To view the anaglyph—

Place the spectacles close to the eyes, green to the right eye, red to the left eye. View with both eyes open, vertically over the anaglyph, at about 18 inches distance. If the appearance of relief is not seen at once, slowly increase and decrease the distance until relief is sharp.

STEREOSCOPIC EXAMINATION OF AIR PHOTOGRAPHS

The photographs should be examined on a table between the examiner and the light which, for choice, should be good north daylight.

2. Draw a line across the table, longer than the stereoscope and at a comfortable distance.

3. Place the photographs so that the white line on each print falls exactly over the line on the table, photograph marked LEFT to the left, photograph marked RIGHT to the right and both the same way up as the lettering. (The white line is merely a line drawn from the photo-centre along the line of flight).

4. Place the stereoscope over the photographs.

5. Select some easily identifiable feature which is common to both photographs, such as a stream bend or junction. Place a finger below this feature on each photo and, looking through the stereoscope, move the photos laterally, inwards or outwards still keeping the white line on the photos over the line on the table until the separate images of the two fingers are seen to merge.

6. Then look at the area around the selected point on the photograph and it will be found that the ground shows up in relief. At this stage, relief view may need to be perfected by very minor movement of one photograph.

7. When the photographs are positioned, weight or pin them down and the stereoscope may be moved as necessary to examine different portions of the overlap. Throughout the process, the long side of the stereoscope should be kept parallel with the line on the table.

8. The illustrations in this pamphlet are lithographic half-tone reproductions and are therefore inferior in quality to bromide prints which would be supplied for planning purposes.

On the other hand the white lines are not entered on the photographs supplied for planning purposes but their position can be guessed sufficiently well to enable untrained persons to place the photographs correctly for stereoscopic view if the procedure described in paragraph 5 above is followed.

In order to ascertain which photograph to place on the right and which on the left, when they are unmarked, simply overlap them so that similar detail corresponds. The prints are then in their correct relative position for drawing outwards. If then, on examining through the stereoscope, relief is seen inverted, that is to say hills become hollows and hollows become hills, overlap them again, hold them together and turn them *together* completely around and then separate as in paragraph 5. Correct view of relief will then be obtained.